INTELLIGENT INFORMATION SYSTEMS: A Decade Later

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I. INTRODUCTION

In an article that appeared ten years ago (Zannetos 1968) which was based on an earlier Working Paper (Zannetos 1965 c), I argued for the desirability as well as the necessity for intelligent management information systems and suggested an approach toward implementation. Two years after the Working Paper, Carroll and I (Carroll and Zannetos 1967) on the occasion of a Congress for Information Systems presented a paper which spoke about the realization of such intelligent systems for managerial planning and control.

Among the main thoughts contained in the original Working Paper were the following:

1. The management information systems (M.I.S.) should be probabilistic rather than deterministic in nature. To conform with the probabilistic meaning of information, "management by exception" should be defined as management on the basis of significant probabilistic deviations from statistical patterns of relationships. As a result, "exceptions" should not include all accounting variances but only those deviations which fall outside the normal pattern (are larger than what one would probabilistically expect if the underlying process were under control as originally

planned). And this in order to provide managers with filtered information regarding the areas that are most likely to be out of control so that those in charge may assess whether it is worth their time to enter into the picture, and in general guide them on what to do about it.[1]

2. The length of the reporting cycle should be determined by the frequency with which observations occur and the degree of confidence management wishes to attach to the "standards". Similarly the control limits should not be identical (Zannetos 1964).

3. The M.I.S. should be able to test hypotheses. With such a capability at hand the manager would be receiving information on the applicability of alternative feasible "standards", obtaining assistance in developing and assessing cause and effect relationships and rationally employing his new understanding.[2]

4. A unity may be achieved between accounting and statistical analysis of data. (Zannetos 1964; 1966)

5. Cause and effect relationships and in general causal-diagnostic models should be part of the on-going M.I.S.

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[1] The reader should note that these statements apply as much to the favorable as they do to the unfavorable variances. In the former case "exceptions" indicating that the process "is out of control" imply probabilistically that learning may have taken place which made the previous standard or pattern obsolete.

[2] In other words the manager with the aid of such an information system would himself become more intelligent. "Understanding" and "logic in employing that understanding" are two facets of intelligence that we postulated at the time. (Carroll and Zannetos 1967, p. 151)

6. Information on possible changes in the organization structure for greater effectiveness, should become an integral part of the ongoing information system, and be provided on a routine basis, at regular reporting intervals, in the same manner that operating information is reported.

7. Associative heuristics should be stored into the information system, so that:

   (a) the applicability of more general causal-diagnostic models is brought to the attention of managers

   (b) the opportunity costs of available resources are exploited

   (c) "planning-process control" in addition to "operating-process control" be effected, in order to enable an assessment of the validity of assumptions, goodness of plans and effectiveness of execution of the plans. With such a system, managerial decisions may be better evaluated, a priori, and confounding of causes may be avoided.

   (d) monitoring of critical "external" environmental assumptions which affect the strategic and operational plans of the organization be effectively carried out for sensing significant shifts. In other words, critical information which is now outside the purview of the on-going information system will, under these arrangements, become endogenous and so will be the cause-effect relationships linking these critical environmental assumptions with objectives, plans and operations.

An iterative, hierarchical and recursive approach to implementation was also suggested which:

(i) starts with the acceptance of the most probably "standard" (norm or expected value) as representing the underlying economic process,

(ii) checks on the probabilistic significance of variations from the "standard" to determine the areas which are most probably out of control or outside the norm,

(iii) reports those observations which are outside the control limits as specified by management,[3]

(iv) reverses the argument by accepting the results from operations, and develops new posterior probability distributions for the most likely standards of performance as reflected in the results,

(v) statistically analyzes the variances in terms of the controllable explanatory variables,

(vi) broadens the analysis and the development of functional cause-effect relationships by analyzing the covariances between subunits of the organization and determines the impact on a unit's performance of factors emanating outside that unit,

(vii) checks for cyclical elements to identify critical covariations over time,[4]

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[3] To minimize the probability that "drifts" may go unnoticed heuristics for detection may be introduced into the system and also sampling may regularly take place.

[4] This type of information enables one to develop a flow model of the underlying system and develop cause and effect relationship over time (Zannetos 1965).

(viii) suggests possible organizational adjustments, on the basis of the information revealed by the covariance analysis, in order to reduce the complexity and uncertainty in the total system,

(ix) stores the most probable functional relationships into the information system so that the latter may subsequently perform an automatic causal diagnosis on the basis of variations in the explanatory variables,

(x) develops and stores new standards as a consequence of the new functional relationships and the effected re-organizations, and the process starts all over again.

II. APPLICATION

I wish that I could say, if nothing else for purely selfish reasons, that my suggestions caught the imagination of businessmen and that there are many information systems in operation today with intelligence of the type described above. The fact is that there have been very few as well as limited applications of these ideas and of the three experiments in which I participated none of them continues today.[5]

Of the three applications two of them advanced partially to state (v). The theoretical basis, and some of the findings of these two experiments, were reported in the past (Zannetos 1964; 1965 a; 1965 b; 1966) so I will not repeat them here with the exception of pointing out that I was very surprised at the small number of variances reported to managers which had any probabilistic significance. The

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[5] Within the last year I was visited by a consultant representing the management association of a leading European country, who claimed that they had singled out my suggestions on intelligent information systems as a very promising area of empirical research and wanted to create an impact as well as a reputation for themselves by getting into a position of preeminence. I have not heard what has happened since his visit.

percentage of observations singled out in the first pass averaged in the low single numbers. Another finding was that often the aggregation of accounting is too gross and as a result important variances are muted because they are averaged. Statistical analysis of the means of sub-universes also revealed important shifts in assumptions, technology, cost structure and productivity. As for the reporting cycle, the experiements revealed that significant improvements in the value of information can be obtained if it is not tied strictly to uniform calendar periodicity.

The most ambitious and also the most extensive application was the third one (Zannetos 1965 a). It advanced up to state (vii) as described above and resulted in a reorganization. The questions raised by the statistical covariance analysis motivated the development of a "flow model" of the operations analyzed. This and the cause-effect relationship that were developed resulted in great increases in productivity.[6] As in the case of the other two experiments, however, this also was short lived.[7]

III. WHY THE LACK OF INTEREST

I am prejudiced enough to believe that there were some significant breakthroughs of conceptual as well as methodological nature in the articles and working papers of 1964 through 1968. The evolutionary and recursive approach to the development of intelligence systems, which serve as an extension of human capability, and especially the suggested

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[6] In the case of one department the output increased by 225% with a reduction of 20% in man hours. The system was providing signals to the department on the basis of variations in the activities of another department eight months before the impact of the variations were to be felt.

[7] Strictly speaking, there was a fourth application of the thoughts behind intelligent information systems. The covariance analysis for reorganization was applied to determine the impact of a proposed merger of two banks. This was an *ad hoc* application, however.

approach for generating signals out of the on-going information system for assessing the efficiency of organization structures, are unique.

The design of organization structures is a very critical activity of management to be left to the accidents of ad hoc attention as a result of crises. The proposed measurements, and the automatic development of signals and cause-effect relationships to guide management on issues of organization structure, permit management for the first time to control by exception issues of centralization and decentralization and also delegate the signal generation part of control to the formal information system. And all this, in the process of a hierarchical analysis of the accounting variations of operations from plans. So one might think that managers would have expressed an active interest in these concepts and methodology. The question then is: Why the lack of interest.

Unfortunately, I do not have definitive answers and so I will only raise some hypotheses.

1. Absence of a Healthy Attitude toward Accounting Data. Very few functions of management enjoy the conspicuous position enjoyed by control within organizations. It is either revered or hated. As a result, accounting data are either accepted by top management as infallible and as coming out of deterministic processes, in those organizations where accounting control has a position of dominance, or effectively ignored in organizations wherever the accounting function is a second-class citizen.[8] Although for

[8] It is not too much of an exaggeration to claim that the reason the accounting function survives in some organizations of this type is that it is necessary for financial reporting not because operating managers depend on it for control.

completely different reasons, in organizations where these extreme attitudes regarding accounting data prevail, there will be no attempts to improve the information value of the data generated from operations. One may easily conclude, therefore, that changes and pioneering attempts toward intelligent management information systems will be most likely undertaken by organizations which have a healthy respect for the accounting function but not reverence for its "exactness" and "infallibility".

2. Lack of Probabilistic Thinking

Somehow probabilistic thinking seems to be by nature incompatible with managerial mentality. It could be that managers have been conditioned for so long by the seeming exactness of accounting data that a break with the past may not come easy. Managers, also, tend to consider the most recent observation as the one which represents the state of operations. They may not be accustomed to viewing data as part of statistical universes, possibly because their memory is short.[9]

The accounting system tends to reinforce the deterministic view of operations by highlighting current variances and then burying them either in the Income Statement or in the Work-in-Process. A probabilistic view of the results of operations would dictate tracing the variances over the

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[9] Another explanation for this type of behavior may be that managers believe that there is a continuous change within their organizations and therefore no statistical universe can remain stable long enough to justify probabilistic inferences. This will be a natural reaction in the case of managers who assume that the most recent feedback influences operations by encouraging change wherever the necessity for improvement is dictated by the data. Ironically one can make similar arguments, to justify the use of the most recent feedback, in cases where managers have absolute faith in the deterministic nature of operations.

planning cycle and determining whether their expected value approaches zero.

3. Inadequate Training

The application of decision theory and in general of probability and statistics to the field of management is not widely spread. Whatever applications of these methodologies we can single out have occurred only in the recent past. For this reason, not many high-level managers or controllers may have sufficient training in the necessary theory and methodology to understand what we have suggested, adapt it to their own needs and most importantly convince others of the value of "intelligent" information systems.

4. The Role of Computers

During the last twenty-five years we have seen an explosive use of computers in the area of management. While this proliferation was taking place, in parallel, advances in computer technology enabled us to expand the use of computation and at the same time reduce precipitously the cost per type of use. It is an economic law that if the cost of an input decreases relative to that of other inputs, there should be a substitution in favor of the low-cost resource. And so in the case of information, to the extent that it becomes less and less expensive, it should be used in greater amounts in managerial decisions.

The notion behind intelligent management information systems, that probabilistic information (data with an appropriate context) is better than a lot of deterministic data, runs contrary to both the ever-increasing availability of computer-generated inexpen-

sive data and the managerial mentality of wanting to receive "everything available". As Ackoff (1967) pointed out if one were to ask managers to specify what they want to receive they will opt for everything.

So wherever we find it, we must try to change this mentality of management which indicates an inherent insecurity and an aversion to make decisions on the basis of incomplete information. Unfortunately, the present accounting system tends to encourage indecision and waiting "until we have more information", and these tendencies are further exacerbated by the availability of computers which produce more and cheaper data, because:

(a) It does not evaluate decisions on an a priori basis and as a result does not report lost opportunities.

(b) It does not consider the value of the managerial time that is wasted in reviewing a lot of data which have little information content.

(c) It does not separate the impact of assumptions, planning decisions and execution of plans, and

(d) It only traces what has been done and this not in causal terms.

Finally, there is another impact of computers that we must mention. Some managers are still apprehensive about computers and feel that they will be giving up control if they were to delegate to computers the filtering and causal-diagnostic functions.

5. Philosophy versus Analysis

It is not surprising that one of the most significant aspects of our proposals regarding intelligent M.I.S., may also be the

least convincing. We have shown that managers can obtain signals out of the regular reporting system for possible reorganizations. Many managers even today believe that the design of organization structures is in the realm of philosophy and not analysis. The work of Barnard (1938), Simon (1954), March and Simon (1958), Chandler (1962), Lawrence and Lorsch (1967), Emery (1969) and Jay Galbraith (1969) which has no doubt introduced elements of analysis into the design of organization structures, is yet to be fully exploited. By comparison, the implications of my work are far more radical in that a formal linkage, both theoretical as well as methodological, is made between organization structures and control systems. It may take many more years before managers accept such a radical proposal. If, however, some large firms were to design intelligent systems of the type I have suggested, the strength of imitation will no doubt accelerate the broader adoption.

6. Practical Problems with Data

There are several practical problems with data which may impede progress toward intelligent information systems but none of which in my estimation is insurmountable. Some of these problems are:

(a) The lack, in most cases, of a statistical universe, sufficiently large for a cross-sectional analysis of data.

(b) Whenever homogeneous cross-sectional data are not available and one has to resort to time-series data, impurities due to changes in technology and external environmental assumptions may affect the characteristics of the probabilistic distributions.

(c) The choice of the appropriate "control limits" for the identification of probabilistic exceptions, and the definition of the variables to be used in explaining the variations in performance, must fall on the shoulders of managers who are often unwilling to make a choice, because of fear of being proven wrong.

Ironically, the stringency of the data requirements is far greater when these are to be used in a deterministic rather than in a probabilistic sense. A manager, for example, must have much more faith in a "standard" if he were to use it to measure and ascribe deterministic significance to each and every deviation from it, than in the case where he uses it to assess the probabilistic significance of variations.

7. Problems of Manager-System Interface

In spite of the great strides that have been made in bridging the gap between programmers, systems analysts and managers, there is still a lack of communication between them because of the absenc of a common language. Within most organizations managers are not as yet educated in computers and those who know about computers kno little about management. Managers and computer-based systems designers must communicate, as a result, through intermediaries. This is very uncomfortable for managers and in most cases they abdicate and allow non-managers to determine the characteristics of managerial systems. The end result is a set back for those systems which are intended to serve as an extension of managerial capabilit

and which need managerial input and interaction both for the purpose of designing them as well as using them.

8. Visibility

Because of their attributes, intelligent information systems allow more visibility as well as accountability of managers. The potential elimination of privacy and the exposure of one's activities to the scrutiny of others is often very threatening. This is another possible explanation for the lack of progress.

9. Our Own Failures

Finally, I must admit that I may not have tried as hard as I should to "sell" these ideas and convince managers to adopt them. The only excuse for this failure is that often organizations are so consumed with firefighting that there is no time to think about fire prevention. So an outside consultant or researcher cannot very well assume the role of the missionary while fires are burning. Furthermore, maturity in the notions behind intelligent information systems must precede their adoption. I found from experience that such maturity cannot be gained overnight. It often takes years to materalize.

In closing I must admit that I am still very excited about the potential of intelligent management information systems. So I do not want to leave you on a completely pessimistic note. I am confident that what I called intelligent management information systems will be broadly used in the future but only after a lot of patient and diligent proselytization. Obviously, if we excite enough interest and draw the support of a large number of academic and industry people, then that distant day will come considerably closer.

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